

**Citation:**

Yang H, Mokhtari A, Jaykus LA, Morales RA, Cates SC, Cowen P. Consumer phase risk assessment for *Listeria monocytogenes* in deli meats. *Risk Anal.* 2006 Feb; 26 (1): 89-103.

**PubMed ID:** [16492183](#)

**Study Design:**

Meta-analysis / Quantitative risk assessment

**Class:**

M - [Click here](#) for explanation of classification scheme.

**Research Design and Implementation Rating:**

NEUTRAL: See Research Design and Implementation Criteria Checklist below.

**Research Purpose:**

- To identify the most risky consumer food-handling behaviors for deli meats
- To estimate the relative risk of listeriosis to the intermediate-age population associated with these risky food-handling practices.

**Inclusion Criteria:**

Not described.

**Exclusion Criteria:**

Not described.

**Description of Study Protocol:****Recruitment**

The major categories of information used as inputs for the risk assessment included contamination of ready-to-eat (RTE) foods at the retail level, consumer food-handling behaviors, and consumption patterns. Each of these categories had its own individual set of variables.

**Design**

Meta-analysis/quantitative risk assessment.

**Blinding Used**

Not applicable.

**Intervention**

Not applicable.

## Statistical Analysis

- One-dimensional Monte Carlo simulation was used to model variability in growth and cross-contamination of *L. monocytogenes* during food storage and preparation of deli meats
- Using @Risk software (Palisade Co., Newfield, NY), the effect of variability in the input variables on overall risk was simulated. Each simulation consisted of 10,000 iterations for the possible food-handling scenarios. The Latin Hypercube sampling method was applied to sample the input variables from corresponding distributions
  - Modeling Growth: FDA/FSIS risk assessment model used a baseline exponential growth rate ( $EGR_T$ ) at 5 °C and converted this to the EGR at any given temperature T using the following equation:  $EGR_T = ((T+1.18)/6.18)^2 \times EGR_5$
  - Modeling Cross-Contamination in the Home: To consider the effect of cross-contamination on the risk of listeriosis, this study modeled the cross-contamination of RTE foods from two typical sources, the home refrigerator and the hands of the domestic food handler. We assumed that cross-contamination from other sources was less important, and thus was not included in the model. Cross-contamination of RTE foods with *L. monocytogenes* was considered to occur only when two conditions were met: (1) the RTE food comes in contact with a specific surface and (2) the contact surface is contaminated with *L. monocytogenes*.

## Data Collection Summary:

### Timing of Measurements

Not applicable.

### Dependent Variables

- Contribution of different food-handling practices and consumption scenarios to the mean level of contamination (log CFU per gram)
- Contamination of *L. monocytogenes* at the time of consumption
- Mortality from consumption of deli meats.

### Independent Variables

- *L. monocytogenes* contamination at retail (CFU per gram)
- Refrigeration temperature (°C)
- Storage time for unopened vacuum packages (day)
- Storage time for opened vacuum packages (day)
- Storage time for fresh sliced (day)
- Countertop storage temperature (°C)
- Countertop storage time (hour)
- Exponential growth rate (log CFU per day)
- Leftover repeats
- Leftover storage time (hour)
- Proportion over a single meal
- Serving size (gram).

### Control Variables

None.

## Description of Actual Data Sample:

- *Initial N*: Number of articles unclear; 47 references included
- *Attrition (final N)*: See above
- *Age*: Not applicable
- *Ethnicity*: Not applicable
- *Other relevant demographics*: None listed
- *Anthropometrics*: None listed
- *Location*: United States.

## Summary of Results:

### Key Findings

- Simulations approximated that 0.3% of the servings were contaminated with  $>10^4$  CFU per gram of *L. monocytogenes* at the time of consumption.
- The estimated mean risk associated with the consumption of deli meats for the intermediate-age population was approximately seven deaths per  $10^{11}$  servings
- Food-handling in homes increased the estimated mean mortality by  $10^6$ -fold
- Of all the home food-handling practices modeled, inadequate storage, particularly refrigeration temperatures, provided the greatest contribution to increased risk
- The impact of cross-contamination in the home was considerably less
- Cross-contamination via refrigerators and hands did not substantially increase the mean level or prevalence of *L. monocytogenes* contamination in deli meats handled in the study.

### Other Findings

#### *Cross-Contamination and Different Food Handling Practices*

- Results showed that on a relative basis, greatest increase in both contamination level and prevalence of *L. monocytogenes* compared to the previous stage occurred during the first storage stage in the refrigerator
- Fresh-sliced, unopened packages and opened packages of deli meats were assumed to be kept in the refrigerator prior to the first use for up to 14, 90 and 28 days, respectively
- However, countertop storage time was limited to 12 hours and no leftover servings were kept in refrigerator for more than five days
- Thus, more growth was expected to happen during the first storage stage in the refrigerator relative to other home storage phases.

#### *Contamination of L. monocytogenes at the Time of Consumption*

- The model predicted that the probability of *L. monocytogenes* contamination at up to 1CFU per serving at the time of consumption was either 0.998 or 0.977, depending on whether the FDA/FSIS data or the NFPA data were used, respectively, for the initial contamination levels at retail
- Accordingly, based on the NFPA data, 2.3% of deli meat servings had *L. monocytogenes* contamination levels more than 1CFU per serving at the time of consumption, while based on the FDA data this percentage was only 0.2

- Based on the NFPA data, approximately 0.3% servings of deli meats were contaminated with *L. monocytogenes* at levels  $>10^4$  CFU per serving at the time of consumption.

#### *Mortality from Consumption of Deli Meats*

- The distribution of mortality (death per serving) was highly skewed toward the right with a peak around “zero” and a long thin tail extending to the right
- The probability of death in the intermediate-age population from consumption of a single serving of deli meats was  $1.55 \times 10^{-15}$  at 99th percentile, but reached a maximum of  $3.63 \times 10^{-7}$  when taking into account the extremes of the distribution
- Home food-handling increased the mean mortality from consumption of deli meats by approximately  $10^6$  times
- As an example, the mean mortality for the intermediate population associated with the consumption of deli meats increased from approximately nine deaths per  $10^{17}$  servings before home food-handling to approximately seven deaths per  $10^{11}$  servings after home food handling.

#### **Author Conclusion:**

- At-home food handling practices contribute to listeriosis risks associated with the consumption of RTE deli meats
- While the prevalence of contamination at the retail level had the most impact on subsequent risk, temperature abuse, in particular elevated refrigeration temperature, was also a significant contributor to increased risk
- The effects of cross-contamination were less dramatic
- It is clear that small numbers of highly contaminated servings dominate overall mortality. Therefore, controlling both the prevalence of contamination and preventing *L. monocytogenes* from growing to high levels in foods is critical in reducing disease burden.

#### **Reviewer Comments:**

- *Article selection methods and inclusion and exclusion criteria not described. Number of articles unclear*
- *There is currently no consensus on how to appraise the methodologic quality of risk assessment analysis. The quality assessment of this study was done using the quality appraisal tool for systematic review or meta-analysis. Thus the methodologic quality rating of this study may not represent the "true" quality of this study*
- *Based on reviewer's limited knowledge on simulation studies, this article appears to have good reporting on all the parameters in the analyses and provide good explanation for how the model was chosen and how to interpret the results. The assumptions and limitations on the simulation model were also provided.*

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#### **Research Design and Implementation Criteria Checklist: Review Articles**

##### **Relevance Questions**

1. Will the answer if true, have a direct bearing on the health of patients?

Yes

|    |   |     |
|----|---|-----|
| 2. | Is the outcome or topic something that patients/clients/population groups would care about?     | Yes |
| 3. | Is the problem addressed in the review one that is relevant to nutrition or dietetics practice? | Yes |
| 4. | Will the information, if true, require a change in practice?                                    | Yes |

### Validity Questions

|     |  |     |
|-----|--|-----|
| 1.  | Was the question for the review clearly focused and appropriate?   | Yes |
| 2.  | Was the search strategy used to locate relevant studies comprehensive? Were the databases searched and the search terms used described?  | No  |
| 3.  | Were explicit methods used to select studies to include in the review? Were inclusion/exclusion criteria specified and appropriate? Were selection methods unbiased?   | No  |
| 4.  | Was there an appraisal of the quality and validity of studies included in the review? Were appraisal methods specified, appropriate, and reproducible?   | No  |
| 5.  | Were specific treatments/interventions/exposures described? Were treatments similar enough to be combined?   | Yes |
| 6.  | Was the outcome of interest clearly indicated? Were other potential harms and benefits considered?   | Yes |
| 7.  | Were processes for data abstraction, synthesis, and analysis described? Were they applied consistently across studies and groups? Was there appropriate use of qualitative and/or quantitative synthesis? Was variation in findings among studies analyzed? Were heterogeneity issues considered? If data from studies were aggregated for meta-analysis, was the procedure described? | Yes |
| 8.  | Are the results clearly presented in narrative and/or quantitative terms? If summary statistics are used, are levels of significance and/or confidence intervals included?   | Yes |
| 9.  | Are conclusions supported by results with biases and limitations taken into consideration? Are limitations of the review identified and discussed?   | Yes |
| 10. | Was bias due to the review's funding or sponsorship unlikely?  | Yes |

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